BOX NO. 8157

WATER SUPPLY AND LAND USE PLANNING:
CONFLICTING GOALS IN RESOURCES MANAGEMENT

by

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ABSTRACT

The availability of a water supply does not determine the combination of water needs, or land uses, which will be supported by that supply. Water needs vary between uses and water may be reallocated from one use to another. The same amount of water will support a larger population at a higher density due to reduced outdoor use. A reallocation of water from agricultural to domestic and industrial use permits a greater population. Therefore it is not the availability of water supply or lack thereof that permits or constrains growth but rather the political decisions by cities and counties related to economics, social aspects, and land use.

WATER SUPPLY PLANNING AND LAND USE

by Jerri K. Romm[2]

INTRODUCTION

The Santa Clara Valley Water District is a countywide special district with its own planning staff and decision-making body. Its responsibilities in the area of water supply are both social and environmental, including the fulfillment of water quality and quantity requirements for the county.

Santa Clara County is located at the southern end of San Francisco Bay. Once almost entirely agricultural, it now has a growing urban population of over 1.2 million. Sixteen local jurisdictions (cities and the county) are responsible for land use planning and development. These agencies pursue goals which are uncoordinated and frequently conflict on the county level. While most cities draw from the same groundwater basin, land use decisions have been and continue to be made with sufficient water supply assumed.

A history of groundwater mining to meet growing water demands has resulted in a current accumulated overdraft of about 500,000 acre-feet (617 million m^3), land subsidence of almost 13 feet (4m), and saltwater intrusion in the Baylands. The continued development of local and imported supplies and an effective water management program by the District has stabilized groundwater levels in the last 5 years and halted subsidence. Without

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1/ Presented at ASCE Specialty Conference on "Better Cities Through Water Resources Planning and Management", University of Minnesota, August 18-20, 1976.

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authority to control land use or groundwater pumpage, the District's planning role has been passive; its management alternatives crisis-oriented, and its water supply policy traditional: to react to and serve growing demands in order to prevent the environmental damage associated with groundwater mining.

The San Felipe Project is a feature of the Bureau of Reclamation's Central Valley Project. A traditional alternative (importing supply from areas with uncommitted water), it represents an attempt to plan for future water needs prior to the next anticipated crisis. The Project was recommended as the primary source of water for the future after an evaluation of several alternatives described in a recently completed master plan[3/]. The master plan itself sought a greater awareness of social and environmental objectives than had previous plans.

In order to reflect community goals and project future water demands, the District used data on population projections, residential density, employment, and available land provided by the Santa Clara County Planning Department. For the planning period of 45 years, a continuation of the low-density, suburban lifestyle was assumed along with the continuation of a viable agricultural sector in the county.

The concerns of environmental groups, frequently in conflict with urban planning projections, were also included and served to modify the eventual water demand projections. The first important decision was that the lowest of the three population projections

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[3/] "Master Plan: Expansion of In-County Water Distribution System", Santa Clara Valley Water District, December 1975 used by the County Planning Department was chosen so that the project would not be considered growth-inducing. Second, contrary to the trend, per capita consumption was not assumed to increase, and third, other significant water savings were assumed to be achieved in the future. Fourth, two conceptually different alternative sources were examined for extending the community water supply: water savings and wastewater reclamation. Evident throughout the plan was the District's own objective to prevent further overdraft of the groundwater basin.

It was not the master plan, but the draft Environmental Impact Report (EIR)[4/] which led to changes in the District's planning and decision-making process. Prepared by consultants, the draft EIR developed a new population projection which exceeded all others in use, especially the one for which the project was designed. Where the master plan projected low densities and substantial agriculture, the draft EIR had relatively high densities and complete agricultural decline. San Felipe was found to be sufficient to supply both projections.

The public reaction to the draft EIR was adverse. There was substantial disagreement with the high population projections and the concept that all agricultural land would end up in urban use. Growth-inducing impacts were cited in opposition to the project. The energy of the reaction was directed at what was, in fact, a misunderstanding: that the population and land use projections of the draft EIR were those upon which the project

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[4/] "Environmental Impact Report: San Felipe Water Distribution System", Santa Clara Valley Water District, March 1976.

was based and were excessively high to justify the project. It was requested that a lower population projection be used in the final EIR based on lower densities and less available land. The environmentalists assumed that the result of such an analysis would render the project unnecessary and prevent growth-related environmental impacts.

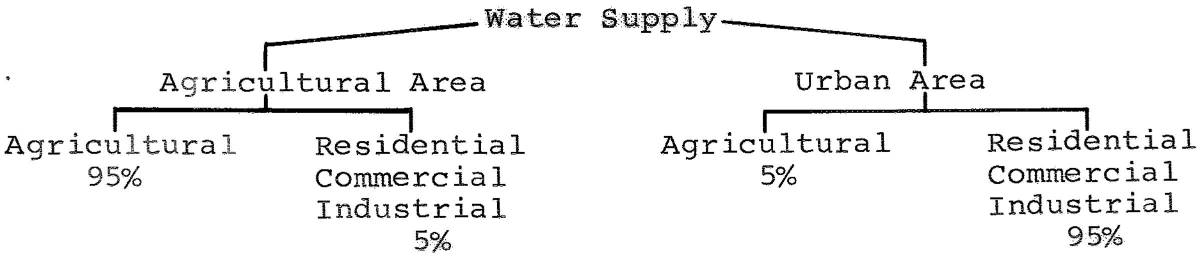
In an attempt to clarify the issues, the District undertook an analysis in the final EIR of the relationship between water supply, land use, and urban growth. This included looking at two prevalent assumptions: that the use of a particular population projection to arrive at future water demand will result in that projection coming true once the water is available, and that the absence of additional water supply will serve to halt growth.

WATER SUPPLY AND POTENTIAL LAND USE COMBINATIONS

A wide range of land use combinations can be supported by a particular amount of water.

Two different regions with identical available water supply are quite likely to have entirely different areas of residential, commercial/industrial, and agricultural land use. Within each of these regions change may occur to bring about a new land use combination still supported by the same supply.

An extreme example of this discussion would be:


Water Supply
Agricultural Area
Urban Area
Agricultural 95%
Residential Commercial Industrial 5%
Agricultural 5%
Residential Commercial Industrial 95%

Water Requirements within Land Use Categories

Within any land use category, there is also a wide variation in unit water requirements.

Agriculture - The amount of water required for irrigation may vary significantly even if the total acreage remains the same.

The major irrigated crops grown in Santa Clara Valley fall into three types: tree and vine, row, and field and pasture. The average amount of water necessary to irrigate one acre (2.47 hectare) or the applied water factor differs for each crop type:

Acreage	Crop Type	Applied Water Factor in acre-feet, per acre, per year	Water Requirement in acre-feet per year
20,000	Tree and Vine	1.7	34,000
20,000	Field/Pasture	2.3	46,000
20,000	Row	3.0	60,000

If the total water available for agriculture was 34,000 acre-feet per year, it would serve to irrigate 20,000 acres of tree ane vine, but only 14,800 acres of field/pasture crops or 11,300 acres in row crops. Even if all the acreage is in one crop type, the specific crops grown may significantly change the water needed. Furthermore, the climate, soil and method of irrigation may result in a different water demand for the same crop in different areas.

Industrial - Water demands from one industry type to another also vary widely. One industry may add less to the county economy but still need more water than another. For example:

_/ One acre-foot = 1233M^3

Industry	Employee	Unit Use in acre-feet per employee per year	Water Use in acre-feet per year
Chemicals and Allied Producte	2,200	2.273	5,000
Electrical Equipment and Supplies	59,000	.085	5,000

Chemicals and allied products industries use about 27 times as much water per employee as electrical equipment and supplies industries.

Residential - Individuals have a minimum daily requirement for liquids of about 2 quarts. This may vary depending upon age, size, climate and other factors. Even individuals living together within a societal framework do not necessarily increase their water use dramatically. Perhaps 50 percent of the world's population use water only for drinking, cooking, and bathing. If the present available residential supply in Santa Clara County were to be divided on this basis (about 15 gal/cap/day), between 10 to 15 million people could be served. If water use by the present population of Santa Clara County was confined to indoor consumption (about 75 gal/cap/day), the present residential supply in Santa Clara County could serve between 3-4 million people.

The degree to which outdoor residential use (primarily irrigation of landscaping) influences the total amount of water consumed is dependent on several factors. A less arid climate may allow substantial landscaping with far less water. Furthermore, no matter how much land is available, personal or cultural preferences will probably place a limit on the area landscaped.

_/ One acre-foot = 1233m^3

Finally, it is evident that families living in apartment buildings, tract homes on 6000 sq. ft. lots and one-acre lots will all have different amounts of land which could potentially be landscaped. Figure 1 shown that outdoor water use in Santa Clara County greatly increases as residential density declines.

Water Consumption as a Function of Residential Density

Three people living in a house situated on one acre will each use more water than three living in a house situated on 1/2 acre. In the house on either lot, each person can be said to use a given indoor amount + 1/3 the amount of water used outdoors. Since the amount of water used outdoors will be greater for the one-acre lot (similar landscaping, greater area), each person there will effectively have a higher unit water use than if he was on the smaller lot.

The following is an example of the amount of water used in a year by 100,000 people in Santa Clara County living at different densities.

Population	Density[1] in persons per acre	Water Use in acre-feet per year
100,000	2.7	33,600
100,000	15.5	16,800
100,000	30.0	14,000

The greatest amount of water is required to supply 100,000 people at the lowest density. Consequently, the lower the density, the more water necessary to serve the same number of persons.

At present, Santa Clara County is confronted by an apparent lack of water to serve a growing population. Most of this growth

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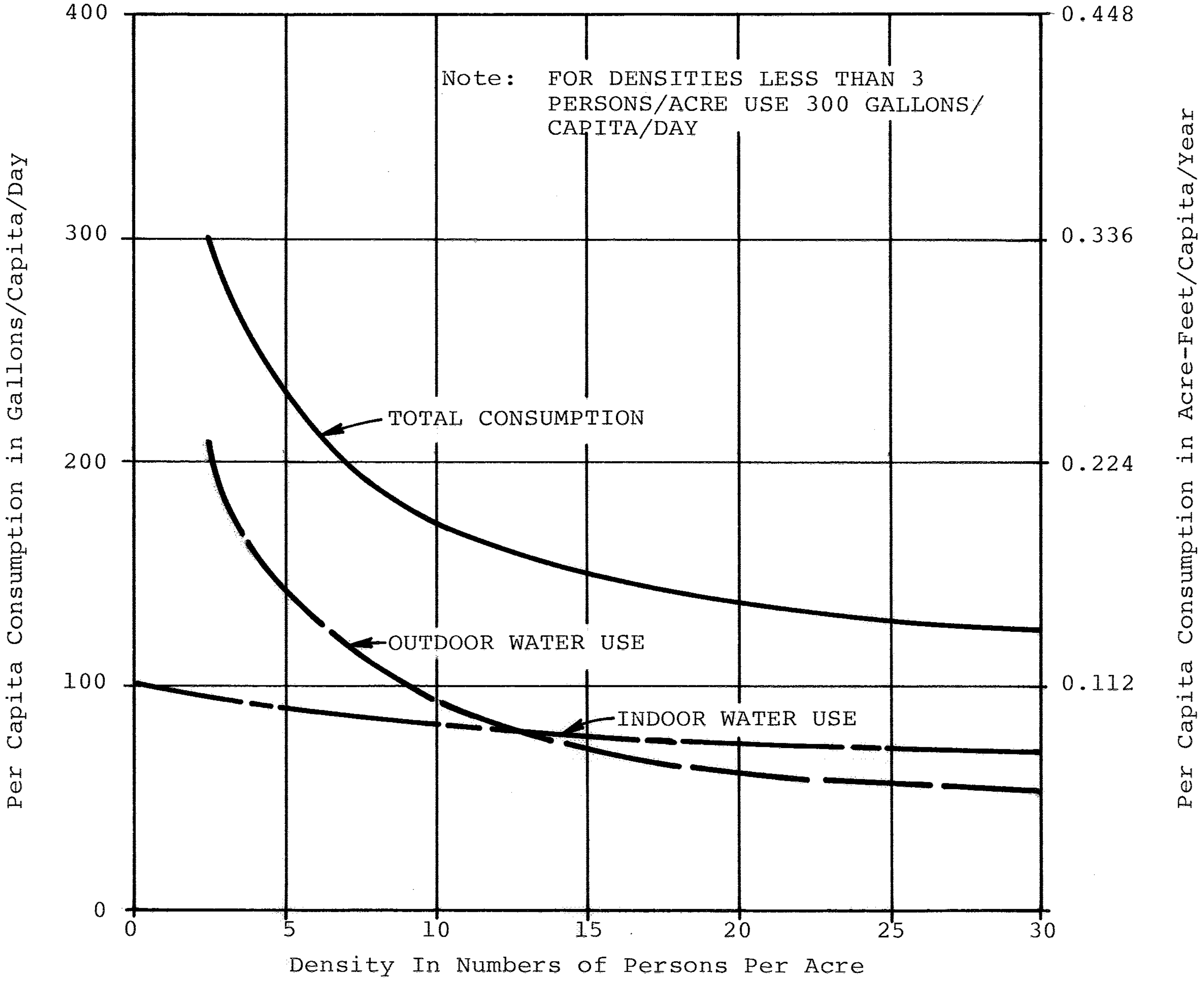
[1] Unless otherwise noted, density will refer to persons per acre.



Note: FOR DENSITIES LESS THAN 3 PERSONS/ACRE USE 300 GALLONS/CAPITA/DAY

FIGURE 1 RESIDENTIAL PER CAPITA WATER CONSUMPTION AS A FUNCTION OF DENSITY

is anticipated to occur through the expansion of residential acres at low densities. If, for purposes of illustration, available supply is assumed to be 33,600 acre-feet per year, it can be seen below that continued growth at low densities will require additional water.

Population	Density[/]	Acres	Water Demand in acre-feet per year
200,000	15.5	12,903	33,600
240,000	15.5	15,484	40,320

However, a growing population could be served by the same available supply if densities were increased on existing developed acreage.

Population	Density	Acres	Water Demand in acre-feet per year
240,000	30.0	8000	33,600

Therefore, under certain conditions, the available water supply is sufficient for new growth, but under others it is not. The result of increasing densities is to continually decrease per capita outdoor use, and achieve increasingly higher populations which can be served by the same water supply.

The higher densities essentially represent a "collapsing" of the amount of land requiring water. This is reflected in the decline of acres in residential development as the density and population increase to utilize indoors that part of the available water supply which otherwise would have been used for landscaping.

[/] Unless otherwise noted, density will refer to persons per acre.

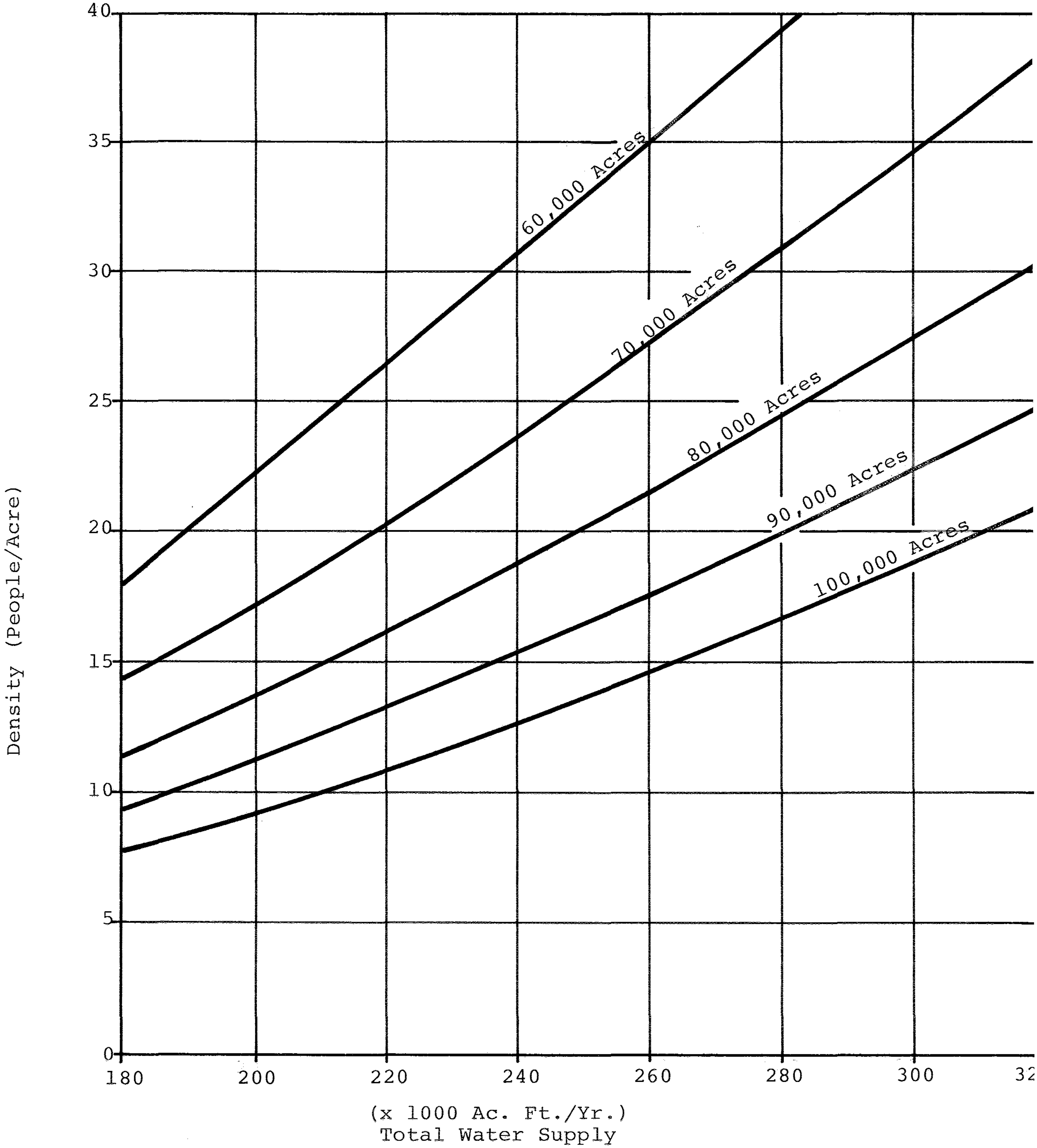
Available Supply in acre-feet per year	Density	Population	Acres Occupied
33,600	2.7	100,000	37,037
33,600	15.5	200,000	12,903
33,600	30.0	240,000	8,000

If the county has a limited water supply and a desired population to be served by it, there is only one combination of density, acres, and population which can fully utilize the water supply_/. For example, a decline in density for the same population will result in more developed acreage, increased outdoor use and in increased water demand. An increase in density has the effect of decreasing outdoor use and lowering water use. Once outdoor use has reached the minimum for Santa Clara County, further increases in density will fail to lower demand. In fact, if both the available residential acreage and the available water supply are limited, there is only one average density which will efficiently use that water supply without exceeding it.

Figure 2 shows the average densities on limited residential acreage which result in the highest population which can be served by a fixed water supply in Santa Clara County.

Since a low population at low densities can actually require more water than a high population at high densities, what will be the relationship between additional water supply and additional growth? If enough water is brought in to supply an increased population of 100,000 at very low densities, the same amount will also provide enough water fo support population growth almost 2-1/2 times greater at a medium density.

_/ There can be several smaller combinations which, when added together, achieve the same result.



RESIDENTIAL DENSITY, ACREAGE, AND WATER SUPPLY

FIGURE 2

Water Supply 1000 acre-feet per year	Population Supported (1000)			
	Very Low Density_/	Low Density_/	Med. Low Density_/	Medium Density_/
33.6	100.0	163.9	206.1	240.0

On the other hand, if the amount of water provided is based on the assumption of the projected population living at medium densities, there will not be enough water to serve that population at any lower density.

Changing Land Use and Water Supply in Santa Clara County

The preceding discussion has shown that a wide variety of land use combinations may exist for a particular water supply. The availability of water appears not to play a role in how the water is used. A few examples of how land and water use are in a state of change in Santa Clara County will illustrate the complexity of combinations and the "role" of water.

Agriculture - Presently, the acreage in agriculture in Santa Clara County is declining. Land devoted to irrigated orchards is declining with a conversion either to row crops, urban use or vacant land._/ This has an effect on water use. Consider the example shown on Table 1.

Although acreage is declining, water demand is increasing due to the higher water requirement per acre on those lands converted from tree and vine crops to row crops.

The conversion to row crops brings a higher financial return and enables agriculture to compete, at least in the short run,

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_/ Less than 3 persons per acre
_/ 9 persons per acre
_/ 17.5 persons per acre
_/ 30 persons per acre
_/ Eventually to become urban

Acres_/ Tree and Vine (1)	Water Use_/ in acre-feet (2)	Acres_/ Row (3)	Water Use_/ in acre-feet (4)	Total Acres (5)	Water Use in acre-feet (6)
17,000	28,900	19,000	57,000	36,000	85,900

CONVERSION TREND

Urban	2500 acres	Tree and Vine	7500 acres	Row

AGRICULTURE - FUTURE CONDITION

Acres Tree and Vine	Water Use in acre-feet	Acres Row	Water Use in acre-feet	Total Acres	Water Use in acre-feet
7,000	11,900	26,500	79,500	33,500	91,400

_/ This does not represent present acreage.
_/ This is based upon average use and would vary between crops.

Table 1

Agriculture - Initial Condition

with urban growth. Since the new crops require more water, it is evident that as long as it is available, water is not the determinant of crop type.

Industrial - The high water use industries are currently holding their own. These are mainly in food, chemical and paper processing. Growth is being encouraged in light industry (which uses less water per employee). However, this growth is occurring on land previously vacant or in agricultural use, adding to the industrial demand. See Table 2.

Both acreage and water demand in industry will increase. However, water use per acre in industry will decline if lower water use industries are those responsible for the increased demand._/

The higher growth rate in low water using industries is related to historical factors, the labor market, and community goals for economic development. Were water to increase in price, or decrease in availability, these industries would probably not be sufficiently affected to relocate.

Residential - The trend in residential development in North Santa Clara County is toward increasing population and increasing residential acreage. The overall average density will remain constant with an increasing percentage of people living at "very low" and "low" densities._/ See Table 3.

Given current trends and policies, water demand will continue to rise since new population is to be housed on newly developed acrea at low densities._/

_/ See page for density categories.

_/ Even if these acres previously were in irrigated agriculture, the water requirement per acre is higher for these combined residential densities than for the agricultural acres replaced.

Acres Heavy Use (1)	Water Use in acre-feet (2)	Acres Average Use (3)	Water Use in acre-feet (4)	Acres Light Use (5)	Water Use in acre-feet (6)	Acres Total (7)	Water Use in acre-feet (8)
400	23,000	7,000	33,000	2,920	5,000	10,320	61,000

INDUSTRIAL GROWTH

Urban Vacant	2000 acres	Average Use Industry	Light Use Industry	500 acres	Agriculture

INDUSTRY - FUTURE CONDITION_/

Acres Heavy Use	Water Use in acre-feet	Acres Average Use	Water Use in acre-feet	Acres Light Use	Water Use in acre-feet	Acres Total	Water Use in acre-feet
400	23,000	9,000	42,500	3,420	5,900	12,820	71,400

_/ These acres are examples, not actual acreage.

_/ While the increase in industrial use for this example is 10,400 acre-feet, the increase in total use would be 10,400 acre-feet less the amount of water previously used on the agricultural lands converted to industry.

Table 2

Industry. Initial Condition

VERY LOW DENSITY			LOW DENSITY			MEDIUM LOW DENSITY			TOTAL		
Population (1)	Acres (2)	Water (3)	Population (4)	Acres (5)	Water (6)	Population (7)	Acres (8)	Water (9)	Population (10)	Acres (11)	Water Use (12)
66.0	11.0	16.2	116.0	11.5	22.5	919.0	44.7	143.4	1100.0	67.2	182.2

NORTH COUNTY
RESIDENTIAL LAND USE - PROJECTED 1990

VERY LOW DENSITY			LOW DENSITY			MEDIUM LOW DENSITY			TOTAL		
Population	Acres	Water	Population	Acres	Water	Population	Acres	Water	Population	Acres	Water Use
122.0	19.8	30.0	174.0	18.3	35.4	1191.0	52.4	181.0	1487.0	90.5	245.5

Table 3
North County
Residential Land Use - 1975
(1,000's)

Water supply has not played a role in the recent decisions by cities to lower densities. The single-family house with sufficient space to landscape remains at the core of Santa Clara County's identity. In spite of the costs of providing services to new low density development, densities above the "medium low" category will not appear in substantial quantity until virtually all available residential land is used up and the stimulus for growth remains.

Water Supply and Population Growth

The purpose of this section is to evaluate the population growth which could be supported by the amounts of water supplied by various water supply alternatives. The results of the analysis discussed below are summarized in Table 4, Growth Potential: Project and Alternatives.

Supply Assumptions - For purposes of this portion of the analysis, it will be assumed that measures are implemented by local jurisdictions to prevent the use of overdraft of the groundwater resources to meet increased demand. Each alternative water supply will be evaluated for the population growth that could occur. Essentially, this serves to absolutely confine water use to the supply defined by an alternative. (Recent history has demonstrated that in water short conditions, rather than take action to halt increased water use, further growth was allowed by drawing on the groundwater storage reservoir. In a sense, in order to allow growth, municipalities "redefined" available supply to include that water in storage in the groundwater basin.)

Column (2) of Table 4 shows total available supply for the Project and each alternative as defined by the condition of "no overdraft".

TABLE 4

GROWTH POTENTIAL: PROJECT AND ALTERNATIVES (ALL VALUES IN 1000's)

(1)	(2) Total Available Supply (AF)	(3) Water Supply to: (AF)			(4) Reallocation from Agriculture (AF)			(5) Population Applying Residential Supply to		
		Resid.	Comm/Ind.	Agr.	Resid.	Comm/Ind.	Agr.	Low	Med. Low	Medium
Alt. One	400.9	217.5	85.0	103.7	282.9	118.0	0	1690.	1849.	2021.
Alt. Two	445.1	256.4	85.0	103.7	326.4	118.0	0	1954.	2133.	2331.
Alt. Three	527.0	338.3	85.0	103.7	349.0	118.0	60.0*	2090.	2281.	2493.
Alt. Four and Project	545.0	356.3	85.0	103.7	427.0	118.0	0	2557.	2791.	3187.

(1) Alternative One is the No Project Alternative.
(2) Assumes no overdraft.
(3) Distribution based on 1980 demand (No reallocation).
(4) Industrial increased to anticipated ultimate demand to maintain residential-employment balance.
(5) Low = 5.7 du/ac. Medium Low = 7.9 du/ac. Medium = 10.8 du/ac.

* Agriculture still exists under Alternative Three, a portion of its supply is made up of reclaimed wastewater which cannot be transferred to serve residential demand.

Table 4

Growth Potential: Project and Alternatives
(All Values in 1000's)

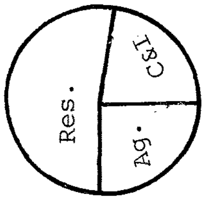
Growth within a Limited Supply - Even if future water demand is limited to the supply defined by each alternative, growth is not automatically constrained. At the point where total demand can no longer be allowed to increase, the total supply will be allocated to residential, commercial/industrial and agricultural uses. Any decrease in the share of one will allow an increase in the share of another. It is therefore possible to redistribute the supply from one use to another.

Reallocation from Agriculture

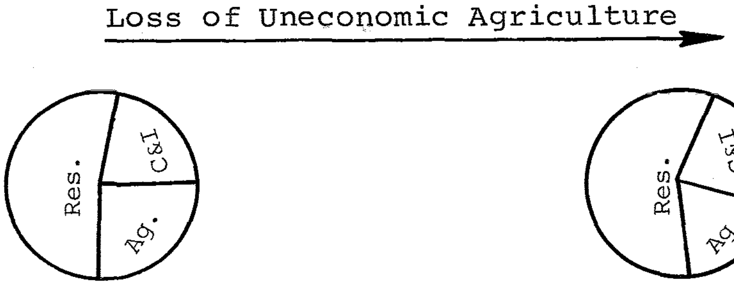
- Protection of Existing Agriculture - A water shortage which limits growth where growth pressures are strong will tend to force a reallocation of water from agriculture to residential and commercial/industrial uses unless there is a commitment by cities to protect all agriculture which could remain viable with sufficient water supply. If agriculture is protected, no supply would be reallocated to increased urban use. The supply available for urban growth would be essentially frozen.

  Column (3) of Table 4 shows the supply distribution for the Project and Alternatives.

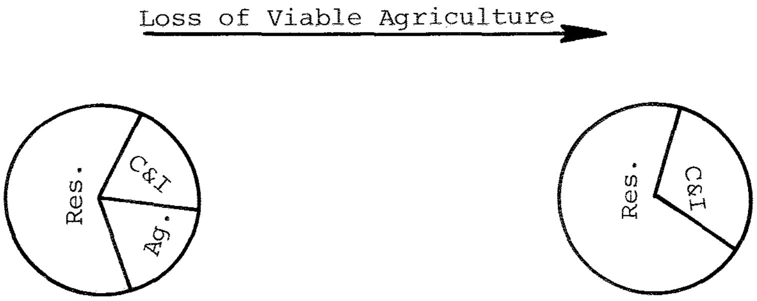
Protection of Existing Agriculture



- Loss of Uneconomic Agriculture - Agricultural lands projected to be lost during the planning period under conditions of insufficient water supply will be phased out earlier, releasing additional water for more rapid residential and industrial growth.



- Loss of Viable Agriculture - If agriculture is not protected, the conversion of otherwise viable agriculture will take place releasing the maximum amount of water which could be made available for residential and commercial/industrial use. The actual conversion of these agricultural lands will be dependent upon population growth levels. The conversion does not necessarily result from pressure for the land itself, but rather economic pressures on agriculture that make it more attractive to the owners of agricultural land to convert it to other uses. This in turn releases water for another purpose. Column (4) of Table 4 shows the maximum supply for residential use under the Project and Alternatives as agricultural use is reduced to zero.



- Reallocation within Residential Supply - At each level of reallocation of agricultural supply, the supply of water available for residential and industrial use is increased without increasing the total water use. The reallocated water is divided between residential and industrial needs since population growth will continue only if employment grows proportionately. It is, however, possible even within the supply allocated to residential use, to increase the population served by changing the patterns of residential water consumption.

  By increasing overall density, a higher population can be served for the same amount of water. Column (5) of Table 4 shows the populations which could be supported at varying densities for the residential watet supply levels of the Project and Alternatives.

The above analysis shows that a fixed amount of water could continue to support growth after its apparent limit had been reached. It is evident that limited water is not a constraint to growth.

It may be that the high populations shown in Table 4 are unrealistic for the county because: (1) agriculture may be protected to some degree for the next 40 years; (2) there may not be sufficient employment to justify the growth; (3) at low densities available residential land will be exceeded; or, (4) higher densities, although within available land limitations, may be unacceptable under city and county policies. However, none of the population levels are unrealistic on the basis of water. All may be unrealistic due to some other type of constraint. It is not the available water supply that would constrain growth, but the way in which that water is used. The way in which water use is distributed depends upon economic and land use decisions made by local governments.

Summary and Conclusions of Water and Land Use Analysis

Available water supply does not determine the combination of water requirements, or land uses, which will be supported by that supply. Rather, it is economics, historical trends, and, at the very center, community goals and associated policies which define and direct the social, economic, and environmental life style of the county. A valley with the existing sources of supply of Santa Clara County has enough water to adequately support any number of land use and population variations. Water supply only becomes "not enough" when it cannot support a set of community goals which are made taking future water supply for granted and which will require a greater supply than is available.

The District has begun to take an active role to achieve optimum implementation of land and water resource development options through integrated planning.

- It is continuing to increase the understanding of the relationship of specific land uses and overall land use patterns to different water requirements. This program includes sets of land uses which are equivalent in terms of water demand. This information not only improves water demand projections, it provides the basis for an attempt to educate urban planners to the impacts on water supply of land use conversions. It also is being used to demonstrate alternative land use combinations compatible with a limited water supply.

- It has completed the first existing land use inventory of the county in ten years. It has also completed a vacant land inventory, in cooperation with the County Planning Department, which projects each vacant parcel's most likely specific future use and the year that conversion will take place. In conjunction with the above analysis of water use factors for different land uses a program has been designed which will annually project distribution and total water demands for the county. The following information represents partial input to the model:

Assessor's Parcel Number
Sub-Areas -- Parcel Location
Land Area (Acres)
Expected Land Use - Based Upon:
    General Plan
    Current Zoning
    Most Likely (City Staff Estimate)
Year of Expected Conversion to Most Likely Use
Unit Water Demand of Most Likely Use

Categories of expected land use are:

Residential Density (du/ac):

Very Low	0.2 - 2.9
Low	3.0 - 5.9
Medium Low	6.0 - 9.9
Medium	10.0 - 19.9
High	20.0 - 48.0
Very High	48.0+

Office
"Neighborhood" Commercial
Strip Commercial & Other Commercial
Shopping Centers
Industrial, Manufacturing, Warehouse, Wholesale
Extractive Industry: Mining, Quarrying
Transportation and Utilities
Public and Quasi-Public Building
Schools
Parks and Permanent Open Space
Agriculture
Not Developable

Population projections will be used only as they reflect the use of the land. The land use data base will be made available to the cities and could result in improved urban planning.

It must be made clear, however, that the integrated planning has still been unilateral planning; that is to say the District has taken on both land and water use planning, needing one to effectively do the other. As work has spread it has become evident that the work done to fill the District's own planning gaps is also urgently needed by others. This includes water purveyors, sanitation districts, the regional planning body, and several statewide agencies.